MASS-WASTING, CLASSIFICATION AND DAMAGE IN OHIO

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The sudden and often spectacular free fall, slide, flow, creep or subsidence of earth materials may be costly in terms of human lives and property damage. Phenomena of this type, variously called "landslide, earthflow or subsidence" are assigned by geologists to gravity controlled movement or referred to collectively as "mass-wasting." This category also includes movement of dry or hard-frozen masses, or snow-laden debris when moved by gravity. Figure 1 illustrates some of these types of movement.

This paper is intended to bring to the attention of laymen and professional men the importance and widespread occurrence of these destructive forces. A brief discussion of damage, origin, prevention and classification is presented, followed by examples in Ohio. It is hoped that the suggested classification will prove useful as an aid to the recognition of different types of mass-movement.

Annually, many highways are blocked or destroyed, soils are ruined and buried in rubble, forest lands are ripped apart, and bridges, dams, buildings and other structures are wrecked or buried by landslides. Every year, especially in southern and eastern Ohio, many thousands of dollars are lost because of this type of calamity. There is scarcely a spring which does not bring reports of landslides in the local press. It seems obvious that this is a subject of grave concern to construction engineers, soils experts, conservation men and many others including the tax paying citizen. Wherever there are slopes that are steep enough, and wherever there is loose rock material, mass-wasting is a potential threat. Such conditions in Ohio are widespread and examples of damage of one type or another are quite common.

Some of the more costly slides or flows are geologic events that occur naturally, the results of heavy rains, earthquakes or erosional processes, and others are the results of man's activities, i.e., poor engineering practice. Most people associate landslides with mountain areas, but not all occur in regions of great relief. Ideal situations are found along the steeper banks of Ohio's river valleys and on the steep slopes of mature terrain in southeastern Ohio. In many of these areas landslides and mudflows locally plague construction engineers when they fail to pay proper attention to the basic principles governing gravity phenomena.

The ingredients for a landslide or related movement are waste rock or rock materials, water, and gravity. The water increases load and, where an unstable slope exists, serves as a lubricant aiding movement. Add the force of freezing and thawing, which expands and contracts the materials, and a sufficiently steep slope where gravity can move the debris and the stage is set for creep, mudflow, or a landslide. Disturbance of vegetative cover, i.e., overgrazing or overcutting, in forested areas may hasten the approach of landslide producing factors. It is difficult to overemphasize the role of water and the fluctuation of temperatures, however, in the development of gravity movement.

Areas subject to earth movement usually have definite visual evidence of past slides, flow, or creep. Irregular hummocky areas and a line of depressions at the base of slopes of 25° or more reveal landslide topography, and a tendency towards future movement exists. Usually a concave slope profile occurs at the top of such a slope and a convex profile appears at the bottom or toe of the hill. The former is the slide surface and the latter is the bulge formed by displaced materials. If the materials involved are clay or fine silt, then slopes as small as 15° or less are susceptible to mass-movement; in fact, clay and silt will flow much like water if sufficiently wet. Trees, fence posts, or telephone poles standing at rakish angles suggest creep or former slides.

Prevention or control of the dangerous types of mass-wasting is a subject which deserves more attention. Since gravity, water, and frost action are the three major elements involved in most of the foregoing types of earth-movement, these should be the point of attack. Water control offers the best possibilities. Proper installation of drainage systems in an area subject to earthflow and slides is essential. Remove or lower the water content and half the battle is won. Lack of water as a lubricating agent and as a source of added weight on an unstable slope should help prevent trouble.

Where slopes are to be developed in connection with routes of travel or structures, where extensive fill is contemplated, and where excavations or cuts in solid

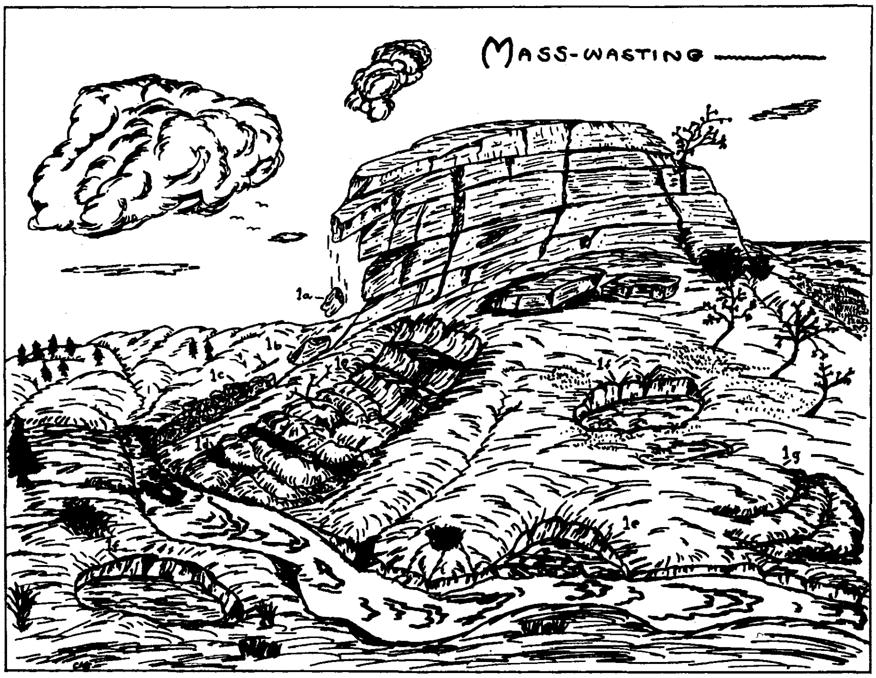

FIGURE 1. An idealized landscape representing several types of gravity movement.

rock are contemplated, early consultation with an experienced field geologist is strongly recommended. A careful evaluation of the mass-wasting potential should be the first step. Properly constructed retaining walls may help in some areas, but even these are sometimes overwhelmed by the power of mass-movement. When the problem concerns erosion of a river bank by undercutting, adequate control of slides may lie in suitable control of the river's lateral sweep.

Early recognition of mass-wasting potential and remedy may lie in the proper consideration of the kind of material, size and condition (i.e., wet, dry or frozen), and the relative speed of movement which could be attained upon the slopes involved. A systematic method of recognizing and classifying types of landslide phenomena is provided in table 1. One should observe the kind of material, relative size, condition and potential speed of movement, then match these data with table 1. It is believed that a little effort will enable the average person to use it to advantage, especially after reviewing the following analysis.

Rock fall is at the top of the list in table 1. It involves larger blocks of angular rock which may fall freely through the air from a rocky cliff to the ground below (fig. 1a). The accumulation may be called talus. *Rock slide* simply refers to the same type of material when it slides along a steep slope (fig. 1b).

Talus- and *rock-creep* are terms applied to smaller rock fragments, usually cobbles, boulders and some finer material which may slide, or creep with slow movement downhill (fig. 1c). Such heaps of debris travel with an imperceptible motion.

Steep rocky walls anywhere are subject to rock fall, rock slide, and talus- and rock-creep. When the rocks are layered, stratified, or jointed, by vertical or horizontal systems, they are subject to weakening by weathering and erosion.

TABLE 1

Classification of landslide phenomena

Kind of Material	Size of Material	Condition of Material	Relative Speed of Movement	Term Applied to Phenomena
Blocky, angular rock	Cubic foot or larger	Wet, dry or frozen	Fast: free fall or slide	Rock fall or Rock slide
Blocky, angular rock with snow	Cubic foot or larger	Wet, dry or frozen	Fast: free fall or slide	Debris fall Avalanche Debris slide
Cobbles, pebbles and soil	Less than a cubic foot to rock flour	Wet, dry or frozen	Rapid slide	Slump slide
Cobbles, pebbles and soil	Less than a cubic foot to rock flour	Wet	Visible flow	Earthflow
Fine silt and clay	1/16 mm. and less	Wet	Visible flow	Slumgullion flow Mudflow
Fine silt and clay	1/16 mm. and less	Wet or semi-frozen	Imperceptible flow or slide	Solifluction Soil Creep
Blocky, angular rock	Usually cobbles and boulders	Wet, dry or frozen	Imperceptible flow or slide	Talus creep Rock creep
Cobbles, pebbles and soil	Less than cubic foot to rock flour	Wet, dry or frozen	Rapid drop to imperceptible subsidence	Sink Wallow Slump depression Compaction depression

During the fall and spring seasons, water penetrates the weakened layers or openings, and freezing sets up a powerful wedging action which rips slabs from the rocky outcrops. These masses of rock and rock material fall, slide or creep down to lower levels.

Debris fall and *avalanche* or *debris slide* are all closely related. Such mass-movement consists of rapid fall, or sliding of a mixture of loose rock debris and snow. Sliding snow or a rolling rock may initiate this sort of movement, which is usually restricted to high altitudes in mountainous regions.

Mass-wasting is an important valley widening process and works closely with the vertical down-cutting action of running water. Along Ohio rivers, *slump slides* occur where the water undercuts an outer bank along a bend (figs. 1e, 2, 3).

FIGURE 2. Slump slide in erosion channel, new filled section.

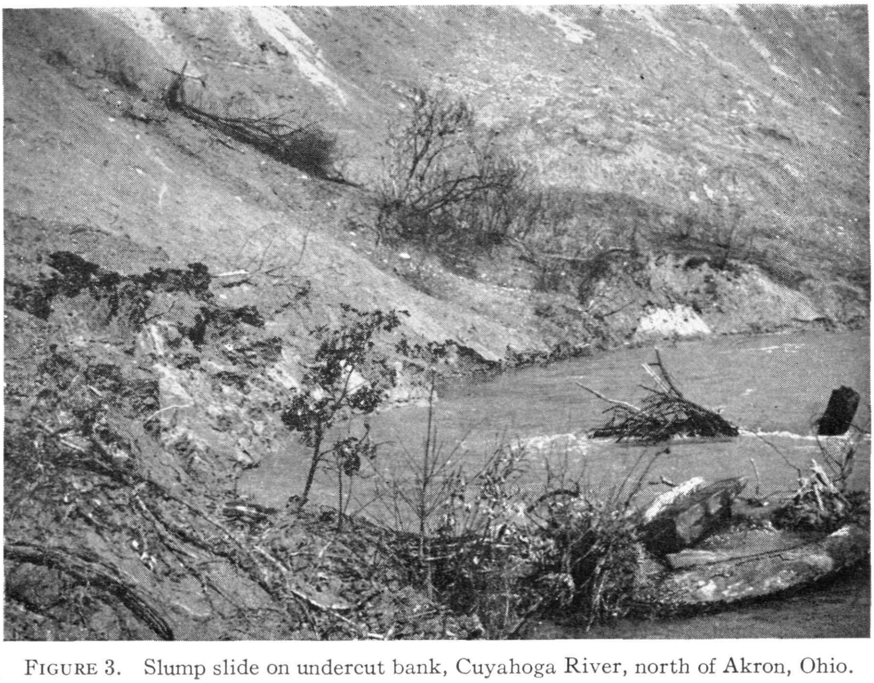

FIGURE 3. Slump slide on undercut bank, Cuyahoga River, north of Akron, Ohio.

FIGURE 4. Earth and mudflow destroying wooded section, Macksburg, Ohio. Note trees set askew, and convex slope on toe of flow.

FIGURE 5. Mudflow associated with earthflow, Macksburg, Ohio.

The sapped bank slumps and slides into the stream and is carried away. Thus the valley grows in breadth.

Earthflow is frequently associated with the foot of a *slump slide* where the latter occurs on hill slopes (fig. 1g). The slump slide moves down and out at the base along a semi-curved bearing surface which may resemble the inner surface of a spoon. Near the bottom of the slope the debris pushes up and out to form a convex surface. Earthflow produces wrinkled and hummocky topography which resembles a wet, bunched-up rug (fig. 4).

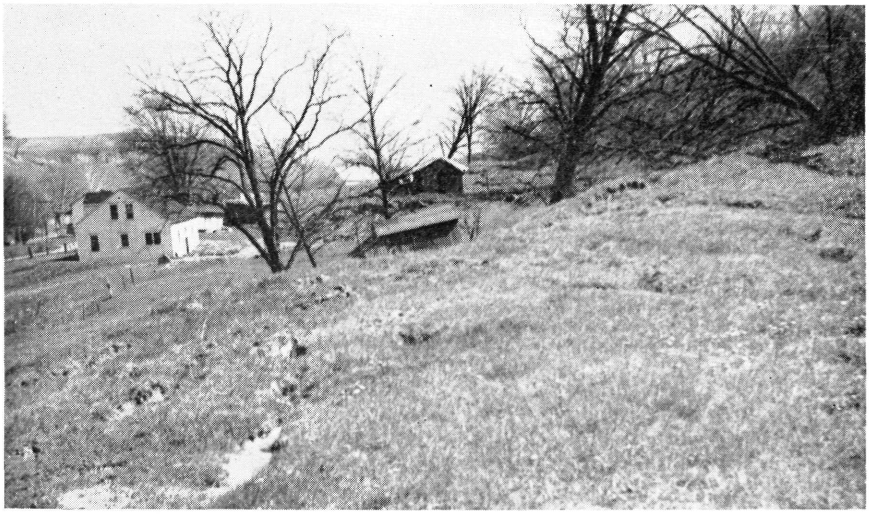

FIGURE 6. Damaged private dwellings trapped in earthflow, Macksburg, Ohio. Note open cracks due to tension.

FIGURE 7. Talus creep and slump slide, the result of strip mining of coal. Macksburg, Ohio. Note destroyed grove of trees.

Mudflow and *slumgullion flow* are quite similar to earthflow, but usually consist of a more "soupy" or colloidal mixture. They usually contain more water and clay or silt. Pools of mud and silt may gather in depressions formed by earthflow (figs. 1d, 5). Earthflow usually includes a foot or more of mantle composed of soil, pebbles and vegetation.

Solifluction and *soil-creep* are related to water and frost action. Solifluction means "soil flow" and is probably more common in regions of permafrost (ground which is permanently frozen except for a few inches at the top), as a slow downslope movement of wet semifrozen soils. In the northerly latitudes one might expect to find solifluction fairly common. Soil creep is a similar process more nearly like sliding, a slow movement of rock and soil downslope, the result of freezing and thawing action which occurs in lower latitudes.

FIGURE 8. Building balanced on edge of slump slide. Note irregular hummocky topography characteristic of slide areas, near Brecksville, Ohio.

Every Ohio farmer is familiar with the work of frost in his fields. In the spring he finds new cobbles and boulders exposed. Frost action has gradually heaved them up through the mantle and soil, and when on slopes they are subject to downhill creep. Freezing expands and lifts coarser fragments vertical to the slope-line, and thawing permits them to sag back towards the earth's center under the influence of gravity. Back-fall occurs at an angle slightly downslope in relation to the direction of original rise. Thus migration takes place in a downhill direction, carrying fence posts that must be straightened in the spring.

In order to present an exhaustive classification of mass movement, it is necessary to include phenomena which are the result of subsidence or the effects of gravity in a vertical direction. The following discussion treats with these forms of movement.

A *sink* occurs in an area of limestone where subsurface solution has developed an underground cavity in solid rock. When the roof becomes weakened and collapses a sink hole is formed. This same sink hole, however, may be the result of solution from the *surface* down and thus technically speaking is not the result

FIGURE 9. Damaged highway department building. This structure had to be torn down. Brecksville slide.

of mass-movement. *Wallows*, "buffalo- or hog-wallows" may be formed on nearly level surfaces by vertical subsidence, due to the weight of grazing or wallowing animals. *Slump depressions* occur as the result of plastic extrusion of soft or fine water-laden sediments, due to the weight of the mantle above (fig. 1f). They are subsidence phenomena as is the type called *compaction depression*. The latter may take place when closer packing of sediments occurs with consolidation due to increase of top load, or simple squeezing out of water content.

Instances of the gravity phenomena described above, too numerous to be cited, may be found in all parts of Ohio. The mechanics of earthflow associated with a specific strip mine near Macksburg, Ohio have been discussed by Savage (1950). Careless operations of mines may endanger water supplies or put mines out of business. As a result of stripping for coal near Macksburg, the natural ground water movement was disturbed and an unsafe slope was loaded with waste or

FIGURE 10. Slide is new highway fill. Concrete slab is undermined. Near mouth of Tinker's Creek, north of Macedonia, Ohio.

spoil and "many cubic yards of earth and mud moved downslope, wrecking two sets of buildings, overriding agricultural lands, destroying a wooded plot, and disrupting a through highway." Figures 4, 5, 6 and 7 are scenes at this site.

The morning papers of February 8, 1950, carried pictures and an account of an expensive slide near Brecksville, Ohio, south of Cleveland. Early in the morning after heavy rains, nearly 500 feet of highway and several Cuyahoga County highway department buildings were wrecked. A long section of the Baltimore and Ohio Railroad tracks was heaved and twisted like damp spaghetti. One private dwelling had to be towed back bodily from the brink of the slide to save it from toppling off a cliff (figs. 8, 9). Preliminary estimates placed the damage at \$500,000. The author viewed the damage soon after the slide took place and in his opinion the slide occurred because of an artifical excavation at the toe of an unsafe slope on clayey silts. This is not the first time such practice has been observed, nor will it be the last. Someone once made an observation which went something like this, "Where there is a steep slope, excavate at the toe, and stand back to see the excavation grow!"

In the spring of 1951, several hundred tons of blue clayey silt in the Horseshoe Glen section of Willoughby Township moved into the Chagrin River. This slump slide occurred when the river undercut and sapped a 100 foot bank. The slumped material formed a 10 foot dam which started to pond water to a level which might have become dangerous to nearby houses, until firemen used a hose to hydraulically wash away the debris and form an outlet.

Similar clayey silt was unwisely used to construct a ramp for a road paved with concrete, near the mouth of Tinker's Creek on the east side of the Cuyahoga Valley. The results were costly, a sizeable slide occurred and a portion of the concrete highway undermined. Extensive repairs will be necessary even before the highway has had much use (fig. 10).

In conclusion, it may be stated that the examples cited above are only a few of the many which may be found in Ohio. References at the end of this paper will be found useful to those who wish to pursue the subject further, or who may wish to read more on the subject of classification, or the engineering aspects of mass-wasting.

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